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## (54) Apparatus for arthroscopic knee surgery.

(57) A surgical system or kit for arthroscopic repair or replacement of the anterior cruciate ligament is disclosed. A preferred embodiment of the invention generally includes means for forming osseous tunnels in the tibia and femur, opening into the intercondylar region. Instrumentation is provided to allow a patellar tendon graft to be harvested from the knee, having bone plugs naturally attached to each end. The graft is secured in the osseous tunnels by an interference fit with a bone screw inserted between the tunnel walls and the bone plugs. Further specialized instrumentation for use with the system is disclosed. Such instrumentation includes : a combination drill for cutting an osseous tunnel and harvesting a bone core, an intercondylar guide for locating a pilot hole on the femoral condyle, single-fluted and multi-fluted hand and power reamers for forming an osseous tunnel, and a work station for facilitating preparatory steps performed on graft material.

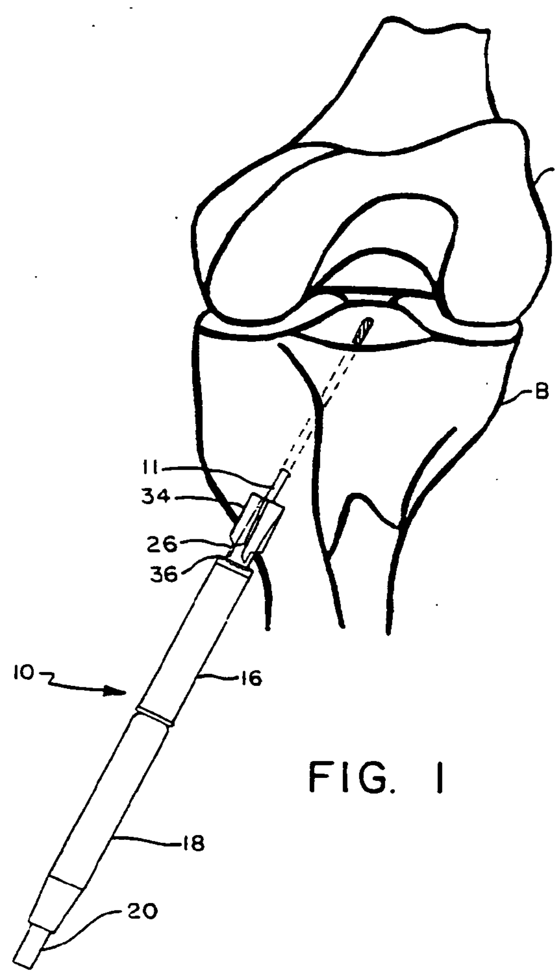


FIG. 1

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## Technical Field of th Invention

The present invention relates to an apparatus for arthroscopic surgery. More particularly, the present invention relates to a surgical system or kit for arthroscopic replacement or repair of the anterior cruciate ligament and the instrumentation associated therewith.

## Background of the Invention

The basis for deficiencies of the anterior cruciate ligament ("ACL") and various techniques of repair or replacement have been known for many years. See, The Anterior Cruciate Ligament Deficient Knee, Clinical Orthopaedics and Related Research, No. 172 (Jan.-Feb. 1983) (J. Feagin, Jr., M.D., Guest Ed.). The great variety of techniques and the non-uniform acceptance of any single technique may have contributed to the lack of specialized instrumentation for performing replacement or repair of the ACL. Instrumentation which has become somewhat specialized in this area is drill guides for locating holes in the tibia and femur. Hewson, Drill Guides for Improving Accuracy in Anterior Cruciate Ligament Repair and Reconstruction, Clin. Orth. Rel.. Res. 172: 119-124 (Jan.-Feb. 1983) presents a survey of various drill guides. However, none of the drill guides available are without its particular disadvantages.

One technique for the replacement of the ACL, which has gained in popularity in recent years, is the use of a graft taken from the patellar tendon and inserted into tunnels reamed in the femur and tibia. This technique is described in Lambert, Vascularized Patellar Tendon Graft with Rigid Internal Fixation for Anterior Cruciate Ligament Insufficiency, Clin. Orth. R l. Res. 172: 85-89 (Jan.-Feb. 1983). In this the portion of the patellar tendon used is separated from the tibia and patella with a scalpel and osteotome. The osteotome is used to separate the graft with small pieces of bone (to serve as bone plugs) naturally attached at each end of the tendon. One problem associated with this procedure is that the osteotome creates V-shaped defects or recesses where the small bone pieces are removed. The V-shape of the defects can create high stress concentration at those points.

Tunnels or holes are drilled in the tibia and femur, both opening to the intercondylar region. Lambert teaches that the most accurate placement of the holes is achieved by drilling both holes from the outside of the bone towards the inside. Lambert also recommends the use of a Hewson intercondylar drill guide for accurate placement of the holes.

Once the hol s have been formed in the tibia and femur, the graft is twisted 180° and pulled through the bone holes by sutures placed through the bone plugs. Th twisting of the graft is important to maintain the isometric function of th graft. The ligament graft is secured in place by interf rence fit of bone screws betw n the bone hole wall and the bone plug attached to the tendon ends. The procedure as described by Lambert is not arthroscopic.

Rosenberg, Technique for Endoscopic Method of ACL Reconstruction (Acufex Brochure 1989), describes a modification of the Lambert technique. The Rosenberg technique is arthroscopic and utilizes a femoral tunnel drilled from below the femur. Rosenberg illustrates the difficulty in locating the center of the femoral tunnel. A method for testing the location to ensure that it will provide proper isometric function of the ligament graft is disclosed, but the location must still be selected without the use of a guide to ensure placement relative to the bone mass in which the tunnel is formed. The location thus depends to a large extent on the skill of the surgeon. While specialized instrumentation is described, it is related only to the method of testing the location for isometric positioning.

Although procedures for repair of the ACL have become relatively common, without special instrumentation, such as guides and reamers, the success of these procedures depends to a greater extent upon the specialized skills of a particular surgeon, more so than if such specialized instrumentation were available. Thus, there has existed a need in the art for a surgical procedure with a range of associated specialized instrumentation to facilitate repair or replacement of the ACL.

## Summary of the Invention

It is therefore an object of the present invention to provide a surgical system or kit, including specialized instrumentation for repair or replacement of the anterior cruciate ligament.

The system according to the present invention generally includes means for forming osseous tunnels in the tibia and femur opening into intercondylar region. A replacement ligament is inserted through the tibial osseous tunnel and pulled into the femoral osseous tunnel. An end of the replacement ligament is secured in both the tibial and femoral osseous tunnels.

In order to form a tibial osseous tunnel, a guide pin is placed through the tibia to define the center line for the tunnel. The tibial cortical bone center line for the tunnel. The tibial cortical bone surrounding the guide pin is removed and the tunnel is drilled through the cancellous bone. A combination drill for forming the osseous tunnel is part of th pr sent inv ntion. The combination drill includes a reamer connected in line with a core drill. The combination drill is placed over the guide pin to allow the reamer to remove the cortical bone. The combination drill is then t mporarily withdrawn from th guide pin and th reamer

remov d. The combination drill is then replaced ov r the guid pin to allow the core drill to contact th cancellous bon . Rotation of the core drill cuts th osseous tunnel and simultaneously captures a bon cor within the core drill.

Formation of the femoral osseous tunnel begins with locating a pilot hole on the medial face of the lat ral femoral condyle. An intercondylar placement guide is provided for this purpose. The placement guide includes a guide tube having a hook shaped means for engaging behind the posterior wall of the femur in the intercondylar region. The engaging means defines a predetermined distance from the posterior wall to the location of the pilot hole. After the pilot hole has been located, it is drilled by inserting a guide drill through the guide tube and into the femur.

Next, a guide hole is drilled in order to guide a femoral reamer for reaming the osseous tunnel. In a preferred embodiment, a power driven femoral reamer has a single cutting flute to facilitate clearing of bone chips and speed the cutting of the device. Alternatively, a hand-operated reamer may be used. Th hand-operated reamer includes a distally extending guide drill which cuts the guide hole slightly ahead of the reaming flutes. Use of the hand-operated reamer therefore does not require predrilling of the guide hole.

A patellar tendon-bone graft for replacement of the anterior cruciate ligament may be provided by removing bone plug portions from the tibia and patella with a portion of the patellar tendon naturally attached thereto. A graft harvesting core drill is provided for this purpose. The core drill has a hollow cylindrical body with sharp teeth formed around only a portion of one end of the body. The sharp teeth are placed against th bone in order to cut the bone plug attached to the tendon. The core drill is oscillated in a semi-rotational motion to prevent the sharp teeth from cutting the tendon. The bone plug portion is received in the hollow cylindrical body of the core drill.

Before insertion into the osseous tunnels, the patellar tendon-bone graft is pretensioned and suture receiving holes are drilled in the bone plug portions. A novel work station is provided including apparatus for performing these procedures conveniently attached to a base-plate and thereby secured for easy use and portability. The apparatus include a guide tube and guide tube holder for facilitating sizing and drilling of the holes in the bone plug portion. Also included in the work station are apparatus for splitting a bone core for use as bone graft material and a bone core knock-out block.

## Brief Description of the Drawing

The f atures and advantages of the invention will be more readily apparent from the following detailed d scription of the preferred embodiments, illustrated in the drawing figures, wherein:

FIG. 1 is a view of a left knee joint, flex d and dissected ant riorly illustrating the positioning of a guid drill and combination drill for forming th tibial osseous tunnel according to the present invention;

FIG. 2 is a partial cross-sectional view of a combination drill according to the present invention;

FIG. 3 is an exploded view of the combination drill of FIG. 2;

FIG. 4 is a view of the left knee joint, flexed and dissected anteriorly, with an intercondylar placement guide according to the present invention in place on the femur;

FIG. 5 is a side view of the placement guide shown in FIG. 4, illustrating its positioning on the femur;

FIG. 6 is a view of a left knee joint, flexed and dissected anteriorly and having tibial and femoral osseous tunnels formed for receiving an ACL graft and also illustrating a femoral reamer and guide drill according to the present invention;

FIG. 7 is a partial plan view of a femoral reamer according to the present invention;

FIG. 8 is a partial plan view of an alternative embodiment of a femoral reamer according to the present invention;

FIG. 9 is an end view of the femoral reamer shown in FIG. 8;

FIG. 10 is an end view of the femoral reamer shown in FIG. 11;

FIG. 11 is a partial plan view of a hand-operated femoral reamer according to the present invention;

FIG. 12 is a partial cross-sectional view of a drill puller according to the present invention;

FIG. 13 is a schematic representation of a tibia and patellar tendon, illustrating the features and operation of the graft harvesting drill of the present invention;

FIG. 13A is a plan view of the end of the graft harvesting drill shown in FIG. 13;

FIG. 13B is an end elevation view of the graft harvesting drill shown in FIG. 13;

FIG. 14 is a plan view of a portable workstation according the present invention;

FIG. 15 is an end elevation view of the bone core splitter shown in FIG. 14;

FIG. 16 is a side elevation view of a ligament graft guide tube and tube holder shown in FIG. 14 assembled for use; and

FIG. 17 is a sid elevation view of the bone core knock-out block shown in FIG. 14.

## Detailed Description of the Preferred Embodiments

FIG. 6 is initially, briefly referred to in ord r to introduce the working environm nt of th present

invention. As shown in FIG. 6, replacement of the anterior cruciate ligament ("ACL") requires th formation of osseous tunnel A in tibia B and osseous tunn l C in femur D. A ligament graft (not shown) is then s cured between tibia B and femur D by anchoring it in the respective osseous tunnels. A preferred means for anchoring the graft is by interference fit of a bone screw between the osseous tunnel wall and a bone plug attached to the graft end. In this respect, the procedure of the present invention is similar to the Lambert technique described above. The various steps of the procedure, and instrumentation associated with each step, according to the present invention are described in detail below, approximately in the order of performance or use.

A standard tibial drill guide may be used to properly position a guide drill and drill a guide hole for the formation of tibial osseous tunnel A. This is accomplished by standard procedures, understood by those skilled in the art. After the guide drill has been positioned in the tibia, the associated drill guide is removed, with the guide drill left in place. In the prior art, a standard cannulated drill bit would be placed over the guide drill to drill the osseous tunnel. However, as shown in FIG. 1, in the present invention combination drill 10 is placed over guide drill 11 to form tibial osseous tunnel A.

Combination drill 10, shown in detail in FIGS. 2 and 3, is fully cannulated, with cannulation 12 extending throughout its length. Guide drill 11, shown in FIG. 1, is received in cannulation 12. Combination drill 10 includes plunger 14, which extends through core drill 16 and extension sleeve 18. Portion 20 of plunger 14 extends beyond the proximal end of extension sleeve 18 and is received in the chuck of a standard power drill. Plunger 14 has male hex part 22, received in female hex socket 24 in core drill 16, to transmit driving power from plunger 14 to core drill 16. Combination drill 10 also includes reamer 26 at its distal end. Reamer 26 has a cannulated reamer body 27 and fluted head 28. Driving power is transmitted to reamer 26 through key 30, received in slot 32 of plunger 14. Key-slot connection 30, 32 allows reamer 26 and plunger 14 to be removably secured together without relative rotation therebetween.

In the formation of tibial osseous tunnel A, combination drill 10 is initially utilized with all of the above described components, as shown in FIG. 1. Combination drill 10 is placed over guide drill 11 in the tibia as described. Portion 20 is chucked into a standard power drill (not shown) and rotational power is positively transmitted to reamer 26 through plunger 14 and key slot connection 30, 32. Reamer flutes 34 cut away the cortical bone of tibia B.

Once the cortical bone is removed and the cancellous bone xposed, combination drill 10 is temporarily withdrawn from guide drill 11 and reamer 26 is removed from plung r 14 by disconn cting at key-slot conn ction 30, 32. Combination drill 10 is laced on guid drill 11 with sharpened teett distal end of core drill 16 contacting the c bone of tibia B.

Combination drill 10 is again rotated by drill and core drill 16 operates as a hole saw tibial osseous tunnel A. During the cutting bone core (not shown) is received within h drill 16. After the tibial osseous tunnel is con bone core is removed from core drill 16 by combination drill 10 from the drill chuck an forward plunger 14 to eject the bone core. core may be saved for use as graft material ing bone defects arising from concomitar steps. This use of the bone core is explaine below.

After tibial osseous tunnel A is complet osseous tunnel C is formed. As shown in Fl 5, intercondylar placement guide 40 is use femoral osseous tunnel C with respect to th wall E of femur D in the intercondylar region is preferably flexed at about 60°, although flexure may vary, depending the size of the particular practice of the surgeon, to bey Placement guide 40 helps ensure that the subsequently drilled enters the cancellous not the medullary canal. Placement guid helps to guarantee a minimum thickness fc erior wall of the femoral osseous breakthrough in the posterior wall can mak or impossible to achieve the proper interfer tween the bone screw and bone plug inser steps.

When an ACL is replaced or repaired arthr cally, it can be difficult for the surgeon to posi femoral osseous tunnel because the location s not be physically sized or measured to provide fic reference points. Placement guide 40 is through a medial port in the knee, generally in FIG. 4. Hook 42, mounted on hollow engages posterior wall E of femur D as sho 5. A sharp burr 46 assists in positioning the preventing slippage. Handle 48 facilitates guide.

Once placement guide 40 is in place, 49, preferably about 2.4 mm in diameter, through shaft 44 to drill a pilot hole abo deep in the intercondylar notch. Again, t preferably flexed at about 60°. The pilot the center of the osseous tunnel that is to It is preferred that the pilot hole be positic m dial face of the lateral femoral condyl size intercondylar plac ment guides are p varying the distance between the center and the inside hook of 42, shown as dime FIG. 5. In this mann r, the surgeon has th selecting the posterior wall thickness F f ous tunnel C' to be formed.

Once the pilot hol has been formed with intercondylar placem nt guid 40, th cortical bone is remov d with a known cortical bone ream r by methods understood by persons skilled in the art. The diameter of the cortical bone removed should be the same as the diameter of the femoral osseous tunnel desired.

After the cortical bone has been removed, the surgeon has a number of options in forming femoral osseous tunnel C according the present invention. First, the surgeon must select the approach for reaming the femoral osseous tunnel. Two approaches are possible: a reamer may be inserted through tibial osseous tunnel A, with the knee flexed at about 60° (as shown in FIG. 6), or alternatively, a reamer may be inserted through a medial port in the knee, with the knee flexed at about 90° to allow the reamer to clear the proximal end of the tibia. The latter approach may be required in small knee joints.

Once the approach has been selected, the surgeon must decide whether to use a power or hand reamer. Two alternative embodiments of a power reamer according to the present invention are illustrated in FIGS. 7 and 8. An embodiment of a hand reamer according to the present invention is illustrated FIG. 11. Hand reaming offers technical advantages such as a greater feel for the tunnel as it is reamed, the ability to alter direction of the tunnel and thus greater ease in avoiding the posterior artery. Power reaming has the advantages of speed and minimizing fatigue of the surgeon.

With the power reamer embodiments shown in FIGS. 6, 7 and 8, the surgeon begins by drilling a guide hole using preferably a 2.4 mm guide drill. A preferred guide drill 54, according to the present invention, is shown in FIG. 6. Guide drill 54 has an eye-loop 56 at the trailing end for pulling the ligament graft through tibial osseous tunnel A and into femoral osseous tunnel C. This procedure is described in greater detail below. A standard guide drill may also be used, if desired by the surgeon.

A femoral drill guide (not shown) is used to initially direct guide drill 54. The tubular shaft of a femoral drill guide is inserted into the pilot hole formed in the intercondylar notch. The femoral drill guide is essentially the same as intercondylar placement guide 40, except without hook 42 and burr 46. Guide drill 54 is inserted through the shaft of the drill guide and exits the femur on the lateral posterior side, superior to the condyle, as shown in FIG. 6.

According to the present invention, all drilling and insertion of prosthetic or graft ligaments, is done from below the femoral condyle. Contrary to prior art methods advocating drilling from above the femur, the m thod of the present invention av ids large lateral incisions necessary to access the posterior lateral side of the femur. Only a small incision is necessary to allow guide drill 54 to b pulled through. Th method of the present invention thus also avoids puncturing the posterior capsule.

Referring again to FIGS. 6 and 8, after guid drill 54 has exited the posterior lateral side of the femur, cannulated uni-fluted reamer 60 is placed over the guide drill. The guide drill is received in cannulation 62. Single flute 64 extends radially from reamer body 65 to contact the cancellous bone to be reamed in the formation of femoral osseous tunnel C. Drill connection 66, at the proximal end of shaft 68, is chucked into a standard power drill (not shown). Reamer 60 is then powered through the femur following guide drill 54.

Alternatively, reamer 70, shown in FIG. 7, can be used. With reamer 70, a guide drill such as guide drill 54 is first used to drill a guide hole through the femur in the same manner as explained above. However, after the guide hole is drilled, the guide drill is removed. Reamer 70 has a permanent guide pin 72 and solid shaft 74. Guide pin 72 follows the guide hole and keeps reamer 70 on the correct path. Reamer body 76 and radially extending flute 78 are substantially the same as body 65 and flute 64, except for the absence of a cannulation. Reamer 70 also has a drill connection 66.

The flute configuration of uni-fluted reamers 60 and 70 is illustrated in FIG. 9. The use of a single flute allows the overall mass of the instrument to be significantly reduced, thus facilitating use in the tight-fitting spaces involved in arthroscopic repair of the ACL. The diameter of the femoral osseous tunnel can be varied by changing the length of flute 64 without adding extra mass to the body of the reamer itself. Reamer sizes generally may vary from 5 mm to over 15 mm.

Another advantage of the single flute design is the ability to easily avoid the posterior cruciate ligament ("PCL"). Depending on the size of the knee joint and the particular location of the femoral osseous tunnel, symmetrical prior art reamers or drills used in a similar procedure can interfere with the PCL. Reamers 60 and 70 according to the present invention avoid this problem by allowing the single flute to be rotated away from the PCL as it passes that ligament. Once the flute is safely behind the PCL, the reamer maybe rotated to form the osseous tunnel.

The single flute design of the present invention also provides significant advantages in cutting speed and efficiency. A single flute clears bone chips much faster than multi-flute or standard drill designs known in the art. This allows the osseous tunnel to be drilled much more quickly and reduces chattering of the reamer, which can make the instrument difficult to control.

As discussed above, the surgeon may prefer the us of novel hand-operated ream r 86, shown in FIG. 11. Hand-operated reamer 86 generally compris s removable handle 88, tubular r amer shaft 90 with tripl -fluted reamer body 92 and drill coupler 96 attached to reamer shaft 90 opposite reamer body 92.

R movable guid drill 94 is slidably received in shaft 90 and has male hex fitting 98 at its proximal nd. Hex fitting 98 is rec ived in h x socket 100 at th proximal end of the drill coupler 96. Hex fitting 98 and socket 100 prevent relative rotation between reamer shaft 90 and drill guide 94.

When assembled for use, removable guide drill 94 is inserted into tubular reamer shaft 90 and the proximal end of guide drill 94 is received in socket 102 in handle 88. Handle 88 is provided with spring pin 104, which cooperates with annular detent 106 in drill c upler 96, to secure both guide drill 94 and reamer shaft 90 in handle 88. Placement of reamer shaft 90 into handle 88 forces hex fitting 98 into socket 100 and causes drill 94 to extend about 5 mm distally beyond reamer flutes 108.

To ream the femoral osseous tunnel, the distal tip of guide drill 94 is placed in the pilot hole previously formed in the intercondylar notch. Reamer 86 is rotated by hand and reamer flutes 108 follow guide drill 94 through the cancellous bone.

In a preferred embodiment, hand reamer 86 is provided with a triple-fluted reamer body 92 as shown in FIG. 10. With hand-reaming of femoral osseous tunnel C, three flutes provide greater stability in operati n, as opposed to the single flute design preferred f r power reaming.

After the osseous tunnels A and C have been reamed, the knee is ready to receive the prosthetic or graft ACL. As explained above, in order to avoid the necessity of a large posterior lateral incision, both osseous tunnels are formed from below. For the same reason, the replacement ligament is also inserted from below. For example, a patellar tendon graft with bone plugs at each end is provided with a suture loop in order to pull it through the osseous tunnel. For this purpose, guide drill 54, shown in FIG. 6 is provided with eye-loop 56 at the trailing end. After the ligament graft is sutured to eye-loop 56, guide drill 54 is pulled out of the femur with eye-loop 56 passing through both osseous tunnels and pulling the ligament graft with it. To assist in pulling guide drill 54 through the femur, drill puller 120, illustrated in FIG. 12, can be employed.

Drill puller 120 comprises two intersecting tubes 122, 124, formed generally in a T-shape. Tube 122 is provided with internal threads 126 at the end opposite the intersection with tube 124. Clamping rod 128 is inserted into tube 122 and provided with threads 130, which mate with internal threads 126. In order to facilitate removal of guide drill 54 from femur D, drill puller 120 is placed over the guide drill by sliding tube 124 onto the guide drill. Handle 132 is rotated to screw clamping rod 128 against guide drill 54 within tube 124. Drill puller 120 is thus temporarily secured to guid drill 54 and provides a simple hand-grip for removal of the guid drill.

Portions of the present invention are directed in particular to the use of a patellar tendon-bone graft as described b low. How ver, a large part of the instrumentation and method described herein is qually useful with other types of prosthetic ligament grafts. Thus, the present invention generally should not be considered as limited only to use with patellar tendon-bone grafts.

FIG. 13 illustrates the procedure and instrumentation for harvesting a patellar tendon-bone graft for ACL replacement according to the present invention. Core drill 140 is shown in place on the tibia B for harvesting the tibial portion of a patellar tendon graft. Also illustrated in phantom lines is the location of drill 140 for harvesting the patellar portion of patellar tendon graft.

Graft harvesting core drill 140 includes a hollow cylindrical body 142 provided with symmetrical sharpened teeth 144 at the end which contacts the bone. Teeth 144 do not extend completely around the circumference at the end of body 142. A portion 146 of the end is chamfered back to provide a notch or recess 148 having rounded edges 149, as shown in FIG. 13A.

Core drill 140 is placed on tibia B in order to harvest a small bone plug H with tendon G naturally attached thereto. The cutting motion of core drill 140 is an oscillating semi-rotational motion as opposed to a full rotational motion. The oscillation of core drill 140 is illustrated by double-headed arrow 150 in FIG. 13B. This back and forth motion is provided by an oscillating power drill into which core drill 140 is chucked at proximal end 152. By oscillating back and forth very rapidly, the core drill achieves the same result as a common rotating drill, but does not risk damage to the tendon. Rounded edges 149 of chamfered portion 146 prevent damage to the ligament graft G as bone plug H is removed.

The patellar tendon is a relatively wide ligament, thus the ligament graft can be removed from the center of the patellar tendon without significantly effecting the function of the patellar tendon, as is known in art. Core drill 140 cuts only the bone and a scalpel is used to separate the tendon portion of the graft from the tendon which is left attached to the tibia and patella. The same procedure is followed to harvest the patellar end of the graft, except that the direction of the drill 140 is reversed.

The diameter of hollow cylindrical body 142 can be varied as desired to allow the bone plug harvested to range in size from smaller than 7 mm to larger than 15 mm in diameter. Whatever size is used, it will be appreciated that the harvesting of the tendon graft in this manner l aves a semi-circular defect in the tibia and the patella. Prior art techniques, using an osteot me, for harvesting the patellar tendon-bone graft leave V-shaped defects which create areas of stress concentration in the tibia or patella. Due to the relative thinness of the patella, stress concentrations

can b an especially difficult problem. The semi-circular def cts left by th present invention minimize the creation of stress concentrations. Also, the semi-circular defects may be repaired using the bone core resulting from reaming of the tibial osseous tunnel A as discussed above.

If the bone core resulting from the reaming of the tibial osseous tunnel is to be used for repairing d fects, a number of preparatory steps must be performed on the bone core. These steps include removing the bone core from core drill 16 and splitting the cylindrical core into semi-cylinders, in order to approximate to outer contour of the bone where the defect is to be repaired.

To prepare to the patellar tendon-bone graft for placement in the osseous tunnels, a number of steps must also first be performed on the graft itself. Small holes must be drilled in the bone plugs of the graft to accept sutures for pulling the graft into place. Also, the graft must be pre-tensioned in order to perform properly after placement.

In order to facilitate these preparatory steps, the present invention provides a novel work station 155 for simplifying the surgeon's task in each step discussed above. As shown in FIG. 14, work station 155 includes drill guide tubes 154, drill guide tube holder 156, graft tensioner 158, bone core knock-out block 160 and bone core splitter 162. Each of these parts is s cured to base plate 164, for the convenience of the surgeon. Base plate 164 preferably may be anodized aluminum. Handles 165 are provided on base plate 164.

One drill guide tube 154 and guide tube holder 156 are shown in detail in FIG. 16. Guide tube holder 156 is secured to plate 164 for stability. Guide tube 154 inserts into bore 166 and is held in place by spring pin 168, cooperating with detent 170. The patellar tendon-bone graft is placed into guide tube 154 with a bone plug adjacent to perpendicular guide holes 172. Th surgeon or an assistant may then use hand drills 174, which are snap inserted into block 176 also mounted on plate 164 (FIG. 14), to drill appropriate holes through the bone plug.

A selection of different size guide tubes 154 may be provided to accommodate the different size grafts which may be harvested. The guide tubes are snap fit into recesses 163 in base plate 164 to prevent loss and allow for easy removal.

Graft tensioner 158 may be a standard tensioning device, known to persons skilled in the art.

Bone core knock-out block 160 is shown in detail in FIG. 17. Block 160 is also securely fastened to plat 164. Block 160 is used for removing the tibial bone core from core drill 16 of combination drill 10 shown in FIGS. 1, 2 and 3. After tibial osseous tunnel A has been drilled, th toothed end of core drill 16 is placed against flat 180 on block 160. Plunger 14 is then used to push the bone core out of core drill 16 into passage 182 in block 160. Passage 182 is inclined at an angle to horizontal to cause the bon core to slide out and fall into depression 184 in plat 164. This design nsur s that the bon core does not roll away and thus may be easily handled. A rounded depression 186 may be provided to size the bone core.

Before the bone core can be used for repairing defects resulting from harvesting the patellar tendon-bone graft, the bone core is split into semi-cylindrical halves with splitter 162 (FIG. 15). The bone core is placed into bore 188 in block 190 of splitter 162. Bore 188 has a flat V-shaped bottom side 192 in order to ensure centering of the bone core. Splitting wedge 194 is then inserted into block 190 through slot 196 to split the bone core. The remaining portion of bone core, left after the core is cut to length, can be used to close the tibial osseous tunnel at the lower end after the ligament graft is in place.

Unless otherwise stated all components of the apparatus according to the present invention are manufactured from medical grade stainless steel, by techniques known to those skilled in the art.

The detailed description of the preferred embodiments contained herein is intended to in no way limit the scope of the invention. As will be apparent to a person of ordinary skill in the art, various modifications and adaptions of the structure above described are possible without departure from the spirit and scope of the invention, the scope of which is defined in the appended claims.

## Claims

1. A surgical system or kit for repair or replacement of an anterior cruciate ligament in a knee of a human subject, comprising:

   means for forming a tibial osseous tunnel for receiving an end of a replacement ligament in a tibia;

   a tube for locating a pilot hole at a desired point on the medial face of the lateral femoral condyle by placement of an end of the tube at said desired point, said tube having means for engaging behind the posterior wall of a femur in the intercondylar region, said engaging means defining a predetermined distance from the posterior wall to said desired point;

   a drill for insertion into the tube to drill the pilot hole in the femur;

   means for removing cortical bone surrounding said pilot hole;

   means for forming a femoral osseous tunnel, centered around said pil t hole;

   means for inserting the r placement ligament into the tibial osseous tunnel and for pulling an end of said ligament through the tibial osseous tunnel and into the f moral osseous tunnel; and

m ans for securing the replacement ligament in place in the tibial and femoral osseous tunnels.

2. The system or kit according to claim 1, further comprising:

a guide drill for drilling a femoral guide hole beginning at said pilot hole and exiting the femur on the lateral side, superior to the condyle; and

a single-fluted cannulated reamer adapted to be placed over the guide drill and connected to a power drill to provide rotational power, whereby said reamer may be guided through the femur along the guide drill to form the femoral osseous tunnel.

3. The system or kit according to claim 2, wherein said single fluted reamer comprises a reamer body with the single flute shaped and disposed on the reamer body to be initially rotated away from the posterior cruciate ligament and subsequently positioned behind the posterior cruciate ligament prior to reaming the femoral osseous tunnel.

4. The system or kit according to claim 1, further comprising:

means for drilling a femoral guide hole beginning at said pilot hole and exiting the femur on the lateral side, superior to the condyle;

a single-fluted reamer having a guide pin for insertion into the guide hole, said guide pin being approximately equal in diameter to the guide hole and extending distally from the single-fluted reamer beyond the single flute; and

means for connecting said reamer to a power drill to provide rotational power, whereby said reamer may be guided through the femur with the guide pin received in the guide hole to form the femoral osseous tunnel.

5. The system or kit according to claim 4, wherein said single fluted reamer comprises a reamer body with the single flute shaped and disposed on the reamer body to be initially rotated away from the posterior cruciate ligament and subsequently positioned behind the posterior cruciate ligament prior to reaming the femoral osseous tunnel.

6. The system or kit according to claim 1, further comprising a guide drill having an eye-loop at its trailing end for drilling a femoral guide hole beginning at said pilot hole and exiting the femur on the lateral side superior to the condyle, and for pulling said replacement ligament through the tibial osseous tunnel and into the femoral osseous tunnel by suturing an end of said ligament to said eye-loop and pulling guide drill laterally and superiorly out of the femur.

7. The system or kit according to claim 6, further comprising means for gripping and pulling said guide drill out of the femur, including:

a tube adapted to be placed over a portion of said guide drill when said guide drill is positioned to extend partially out of the femur on the lateral side, superior to the condyle; and

means for clamping said tube to the guide drill.

8. The system or kit according to claim 1, further comprising:

an instrument having a hollow cylindrical body for receiving a bone plug, two ends and sharpened teeth at one said end for placement against the tibia or patella with said teeth adjacent to a point of attachment of the patellar tendon thereto;

means for oscillating said instrument in a semi-rotational motion to cause said teeth to cut the tibia or patella and separate a bone plug portion therefrom, said bone plug portion remaining attached to the patellar tendon and being received in the hollow body; and

means for cutting the patellar tendon to remove a replacement ligament having naturally attached bone plug portions at each end.

9. The system or kit according to claim 8, further comprising:

a tubular drill guide defining a tubular space with a central longitudinal axis for receiving the replacement ligament, said drill guide further defining a guide hole with a central axis at an angle to the central longitudinal axis of said tubular space; and

means for mechanically supporting said tubular drill guide, whereby the bone plug portion of the replacement ligament may be alligned with said guide hole and a suture hole drilled in the bone plug portion while it is securely held spaced away from an associated work surface.

10. The system or kit according to claim 1, wherein said means for forming the tibial osseous tunnel comprises:

a guide pin adapted to be placed through the tibia to define a center line for said tunnel;

means for removing tibial cortical bone surrounding the guide pin; and

means for cutting bone adapted to be placed over the guid pin and rotated, said bone cutting means having a hollow cylindrical part with sharpened teeth at one end to cut the tibial osseous tunnel and form a tibial osseous tunnel bone core received in said hollow cylindrical part when rotated.

11. The system or kit according to claim 10, wherein said means for r moving tibial cortical bon compris s means for reaming bon removably connected in-line with and in advance of said bone cutting means, said reaming means also adapted to be placed over said guide pin, whereby rotation of said cutting and reaming means reams away the cortical bone surrounding the guide pin and said cutting and reaming means may be removed from the guide pin with the reaming means subsequently unconnected and removed from the cutting means.

12. The system or kit according to claim 1, wherein said means for forming the femoral osseous tunnel comprises:
a hand-operated reamer-drill having a guide drill adapted to be positioned in said pilot hole, said reamer-drill being means for simultaneously reaming the femoral osseous tunnel and drilling a guide hole to a desired depth when turned by hand; and
a separate drill for drilling the guide hole to exit the femur on the lateral side, superior to the condyle after said desired depth is reached.

13. The system or kit according to claim 12, further comprising cannulated means for reaming bone having at least one reaming flute and a guide drill inserted in therein to extend beyond said at least one flute a distance between about 2-10mm, said cannulated means having means for hand gripping said cannulated means and guide drill, and wherein said cannulated means and said guide drill are locked against relative rotation.

14. The system or kit according to claim 13, wherein said cannulated means has exactly three reaming flutes.

15. A surgical system or kit for forming an osseous tunnel in a human bone and harvesting a bone core for use as bone graft material for repair of bone defects, comprising:
a guide pin adapted to be placed through the bone to define a center line for the osseous tunnel;
means for removing cortical bone surrounding the guide pin in a diameter at least as large as the diameter of the osseous tunnel to be formed; and
a hollow cylindrical tool having a cutting end with sharpened teeth around the circumference of th tool for drilling the osseous tunn l by rotating and guiding said tool through the bone, wherein said hollow cylindrical tool is adapted to receive a bone core as cut and defined by said tool, said bone core being suitable for us as bon graft material.

16. A drill guid for us in surgical procedures related to a human knee and femur, said f mur having an intercondylar notch with a posterior wall, said drill guide comprising:
an elongated hollow tube, having first and second ends, for receiving a drill bit; and
means for engaging behind the posterior wall disposed at the first end of the tube, said means extending radially a predetermined distance from the hollow tube, whereby the drill bit can be positively located said predetermined distance from the posterior wall of the femur in the intercondylar notch by engaging said guide behind the posterior wall.

17. A surgical bone drill for drilling a hole through a human tibia and femur, comprising:
an elongated shaft portion having a length sufficient to extend from below the tibia, through the tibia and femur and out of the femur, superior to the condyle;
means for cutting bone disposed at an end of said shaft portion; and
an eye, adapted to receive a suture, formed by said shaft portion opposite said cutting means.

18. A bone cutting reamer, comprising:
a shaft having first and second ends; and
a single bone cutting flute extending radially from said shaft at said first end of said shaft, whereby said single cutting flute facilitates clearing of bone chips during reaming.

19. The bone cutting reamer according to claim 18, wherein said shaft defines a longitudinally extending cannulation, said cannulation being capable of slidably receiving a guide drill.

20. A bone reamer according to claim 18, further comprising a guide pin fixed to said shaft at the first end and extending from said shaft in-line with and away from said shaft.

21. A hand-operated bone reamer, comprising:
a hollow tubular reamer shaft having first and second ends and defining a longitudinal cannulation;
at least one radially extending bone cutting flute disposed on said shaft at the first end;
an longated guid drill slidably received in said tubular shaft and extending outwardly b yond said at least one bone cutting flute a distance between about 2-10mm;
means for preventing relative rotation between said hollow tubular shaft and said guide

drill; and

handl means secured to the second end of said tubular shaft, whereby said handl means is grasped and rotated by hand to cut a leading guide hole in a bone with said outwardly extending guide drill and simultaneously to ream a hole of larger diameter with said at least one cutting flute.

22. A hand operated reamer according to claim 21, wherein said shaft has exactly three radially extending bone cutting flutes, with said flutes being spaced equally around the shaft.

23. A detachable means for gripping and pulling a drill, comprising:

a first hollow tube having a longitudinal axis and first and second ends;

a second hollow tube having a longitudinal axis and first and second ends, said second tube communicating with and joined to said first tube at an angle to the first tube;

a clamping rod received in said second tube and having a first end capable of extending into said first tube; and

means for securing said clamping rod in said second tube, whereby said drill may be received in said first tube and said clamping rod secured against said drill to prevent relative axial movement between the first tube and the drill and said first or second tubes may be grasped as a handle facilitate pulling said drill.

24. A surgical instrument for cutting away a bone portion attached to a ligament or tendon without unattaching said ligament or tendon from the bone portion cut away, comprising:

a hollow cylindrical body having first and second ends and a longitudinal axis;

sharp teeth formed on said first end and extending only partially around said first end;

a chamfered portion at said first end defining a recess back from said first end, said recess having rounded edges without said sharp teeth; and

means for allowing said instrument to be gripped by a semi-rotational oscillating power source, whereby semi-rotational oscillation of said instrument around the longitudinal axis causes said bone portion to be cut by said sharp teeth with the ligament or tendon undamaged by said contact with the chamfered portion and with said bone portion being receiv d in the holl w cylindrical body.

25. Surgical instrument for forming a bone tunnel and capturing a bone core from said tunn l, said instrument comprising:

means for cutting the bon core including a hollow cylindrical body with sharp teeth at a front end, and adapted to receive a bone core therein;

drive means for transmitting rotational power from a power source to said cutting means, said drive means being slidably received in the hollow cylindrical body and extending from a back end of said body; and

means for reaming cortical bone, including an elongated body and fluted reaming head, said elongated body being received through the front end of the hollow cylindrical body of said cutting means with said reaming head in front of said sharp teeth, said elongated body removably engaging said drive means for the transmission of rotational power, whereby said instrument may be rotated in contact with a bone and cortical bone is reamed away with said reaming means, said instrument may be withdrawn from the bone and said reaming means removed to expose said sharp teeth of said cutting means, said instrument is again rotated in contact with the bone and said cutting means cuts a bone tunnel and captures a bone core form said tunnel in the hollow cylindrical body.

26. A work station for use in surgical repair of replacement of an anterior cruciate ligament of a knee, comprising:

a base member having at least one depression formed therein;

handle means for holding and lifting said base member;

means for tensioning an anterior cruciate ligament graft, said means secured to said base member;

means for facilitating removal of a bone core from a core drill, said means secured to the base and comprising a block defining a bore therethrough inclined at an angle with respect to the base, whereby said core drill may be placed in communication with said bore with said bone core sliding out through said bore into the depression formed in said base member;

at least one hollow tubular drill guide removably secured to said base member, said drill guide providing means for holding a bone plug and guiding a drill into said bone plug;

a supporting block secured to the base member, having a cylindrical bore for receiving said tubular drill guide and means for securing said guide in said bore, whereby said drill guid may be spaced away from said base member; and

bone core splitting means, including a block secured to the base member, said block defining a bone core receiving bore and a slot

aligned longitudinally with said bore and extending from outside said block into said bore, and a blad insertable through said slot into said bore to split a bone core placed therein.

27. Apparatus for splitting a bone core, comprising:

a block defining a bore therethrough having a diameter slightly larger than the bone core to be split, said bore having a V-shaped bottom side for centering said bone core in said bore, said block further defining a slot aligned longitudinally along the center line of said bore and extending from outside said block into said bore; and

a blade insertable through said slot into said bore, whereby insertion of said blade splits a bone core disposed within said bore.

28. An apparatus for holding a bone plug and guiding a drill into said bone plug, comprising:

a hollow tubular body having a central longitudinal axis and defining at least one drill guide hole around a central axis at an angle to the tubular body longitudinal access; and

a supporting block having a cylindrical bore for receiving said tubular body and means for securing said tubular body in said supporting block, whereby a bone plug may be placed into said tubular body and a drill passed through said drill guide hole into the bone plug.

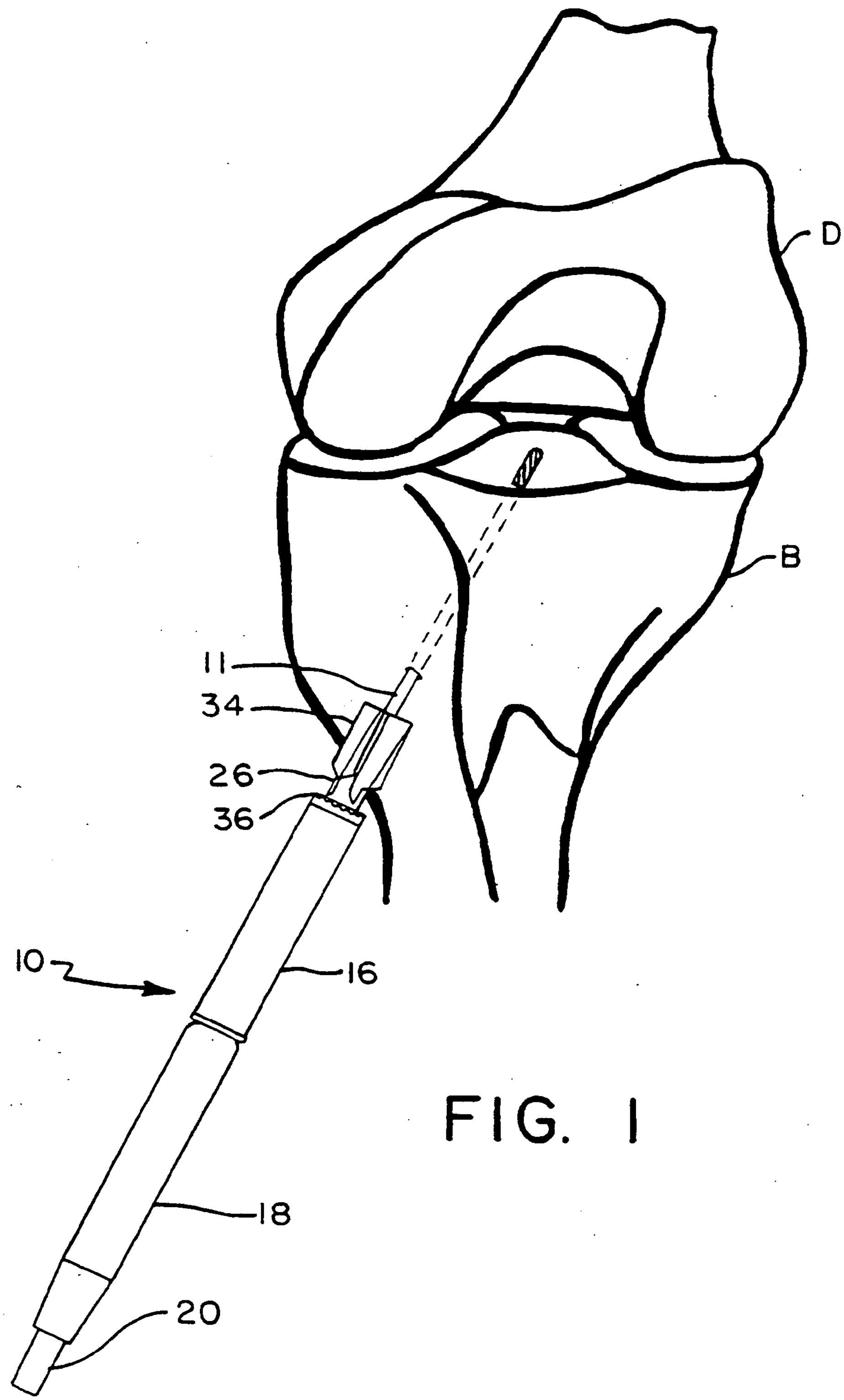


FIG. 1

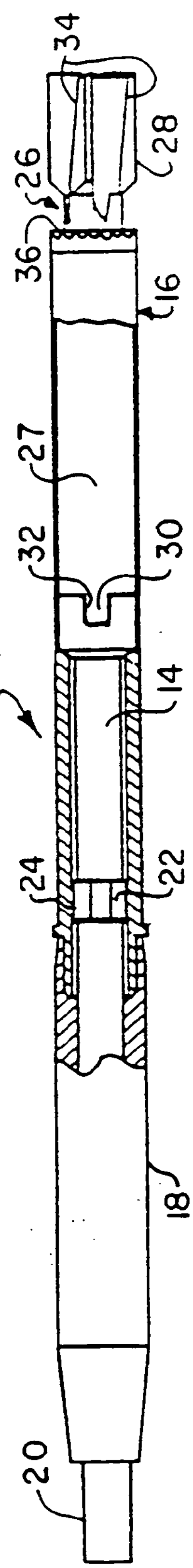
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FIG. 2

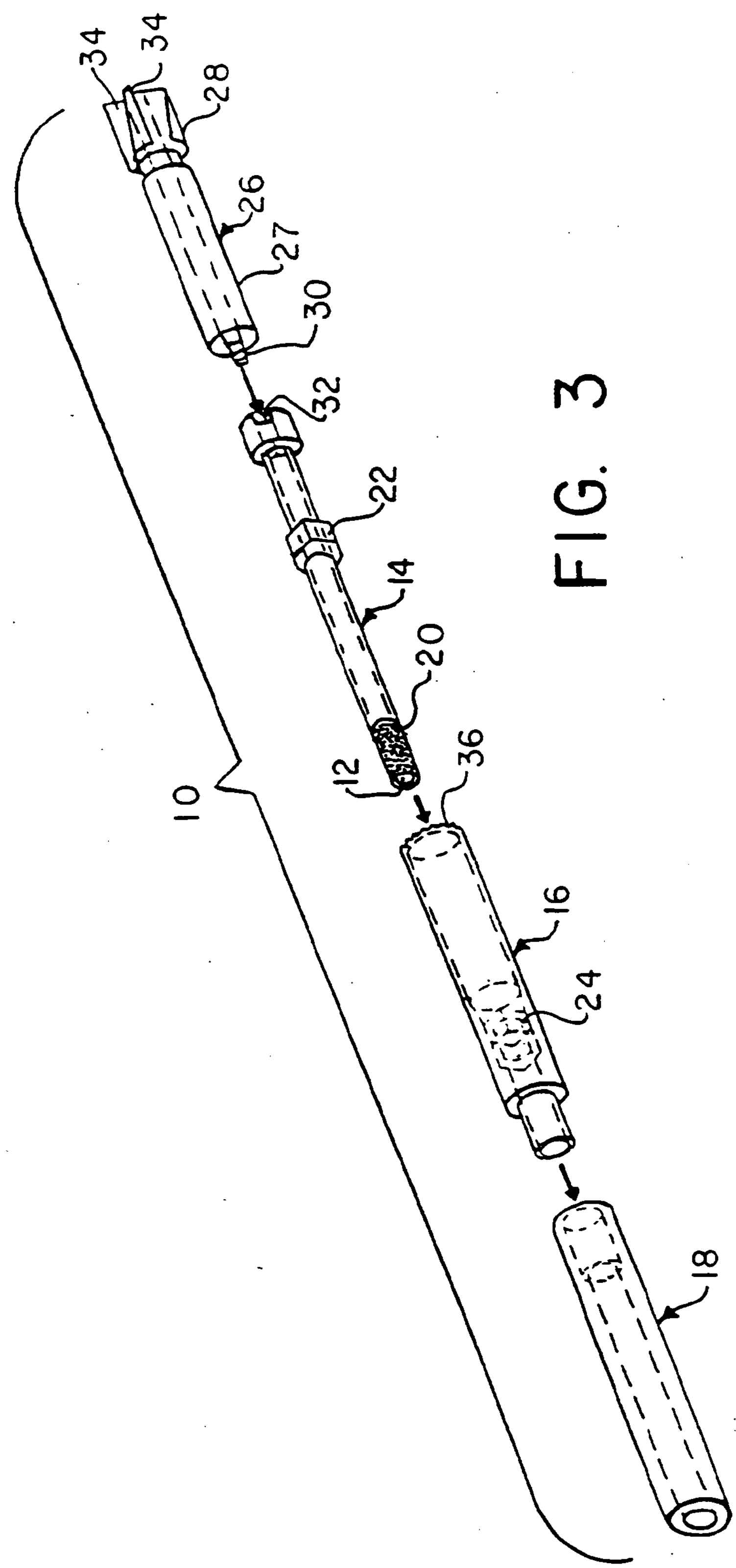
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FIG. 3

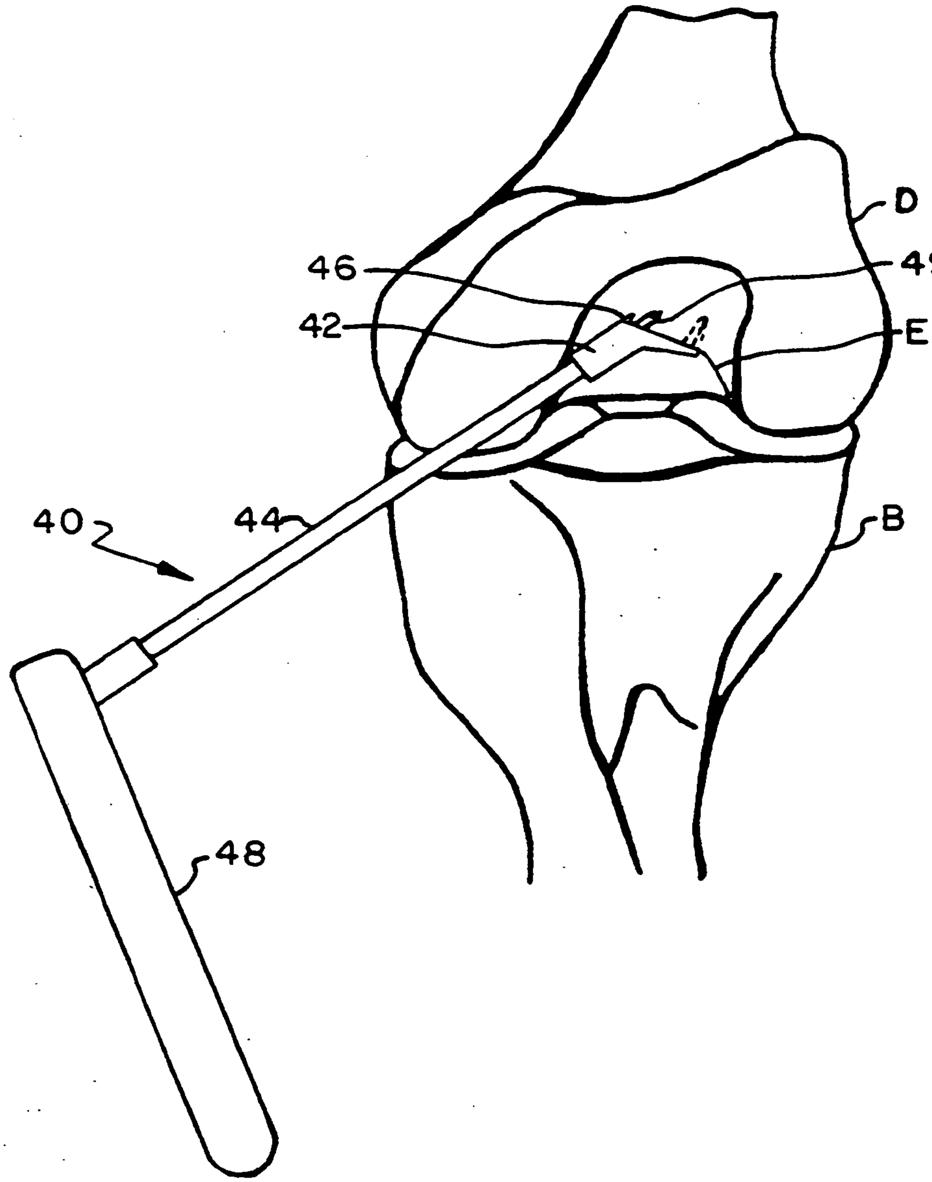


FIG. 4

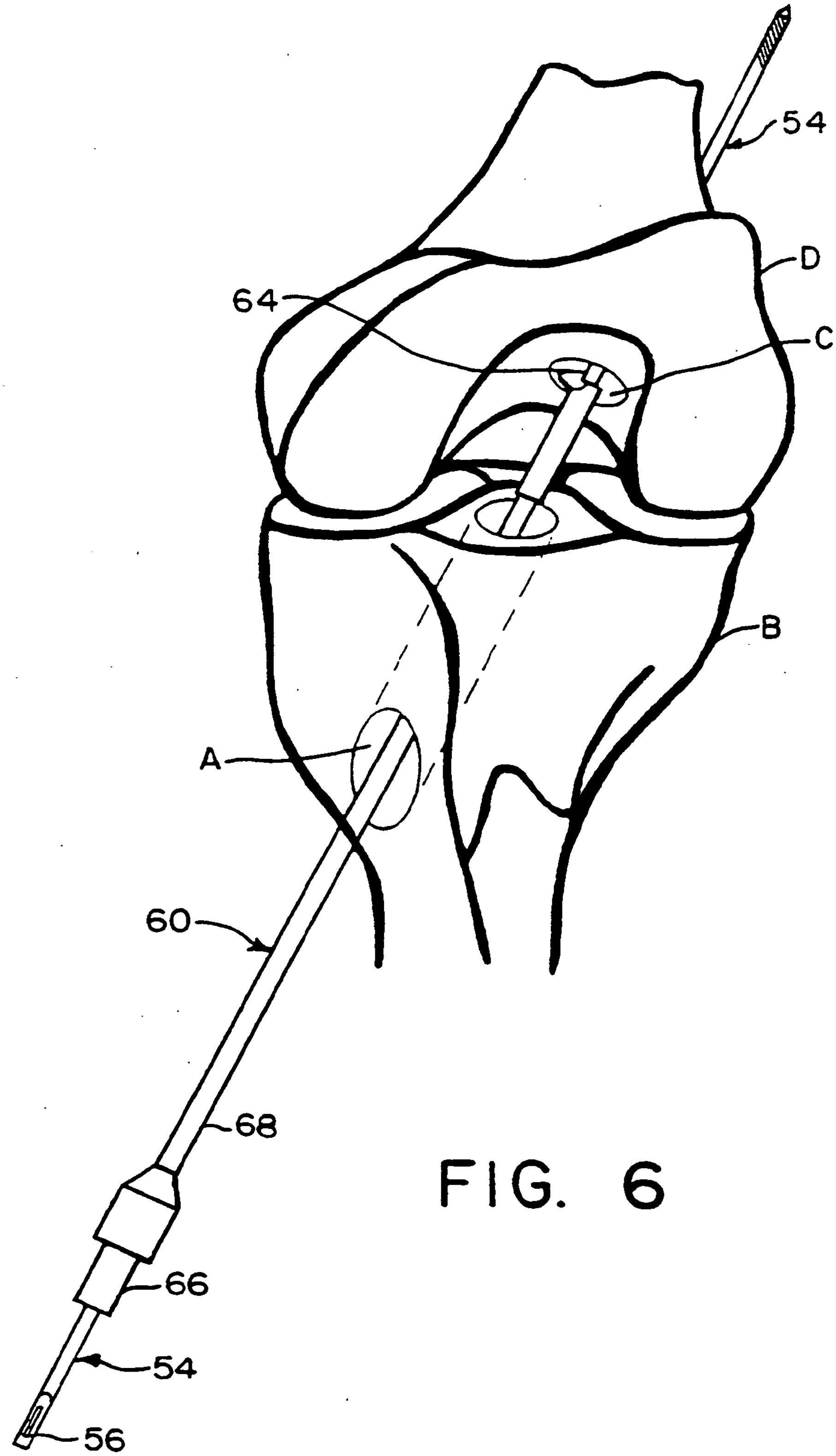


FIG. 6

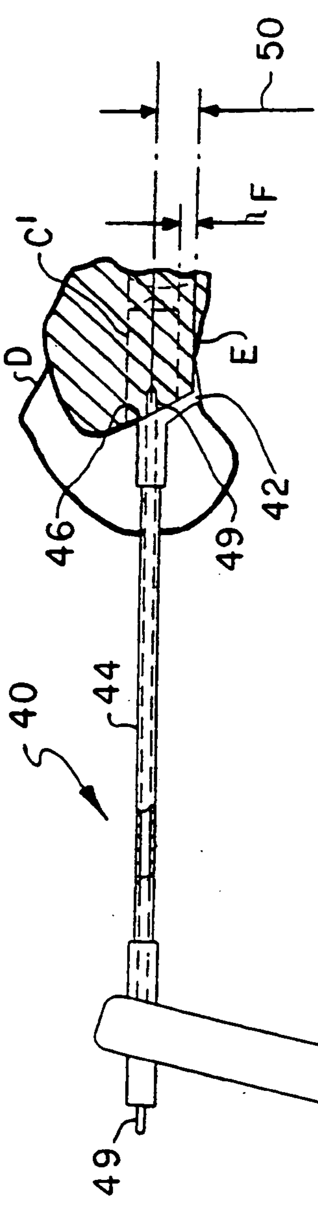


FIG. 5

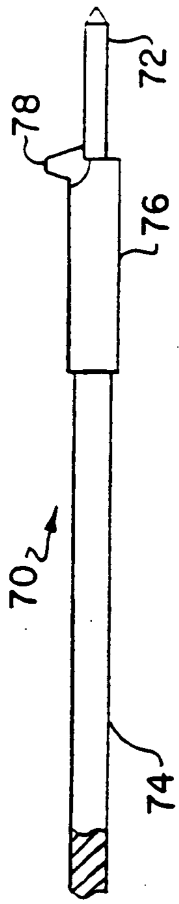


FIG. 7

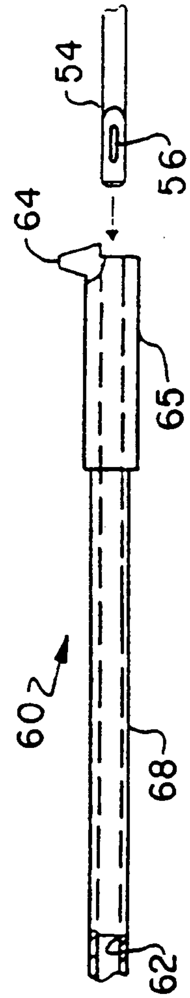


FIG. 8

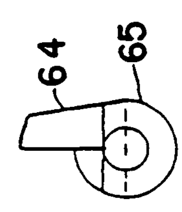


FIG. 9

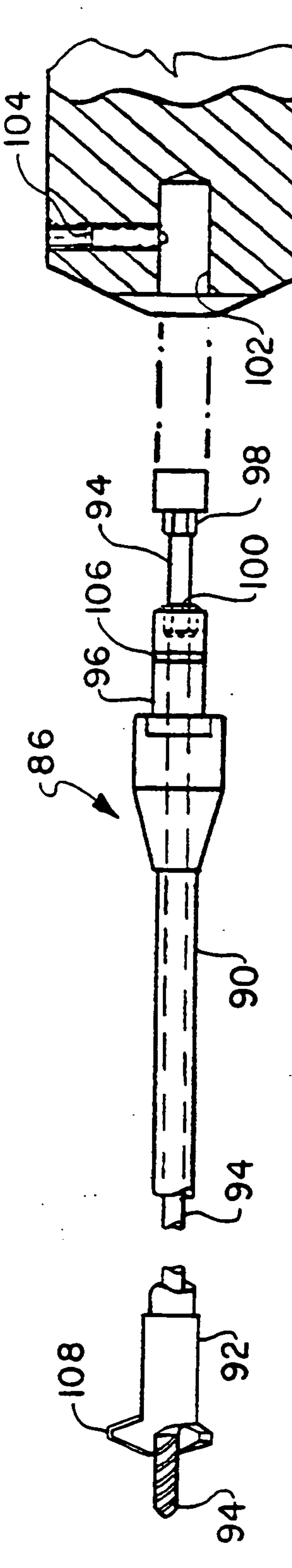


FIG. 11

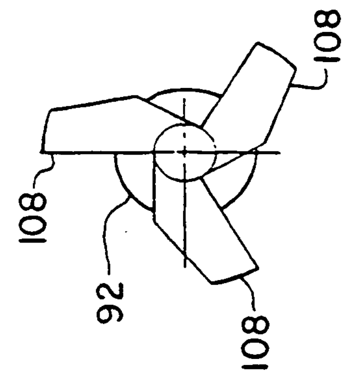


FIG. 10

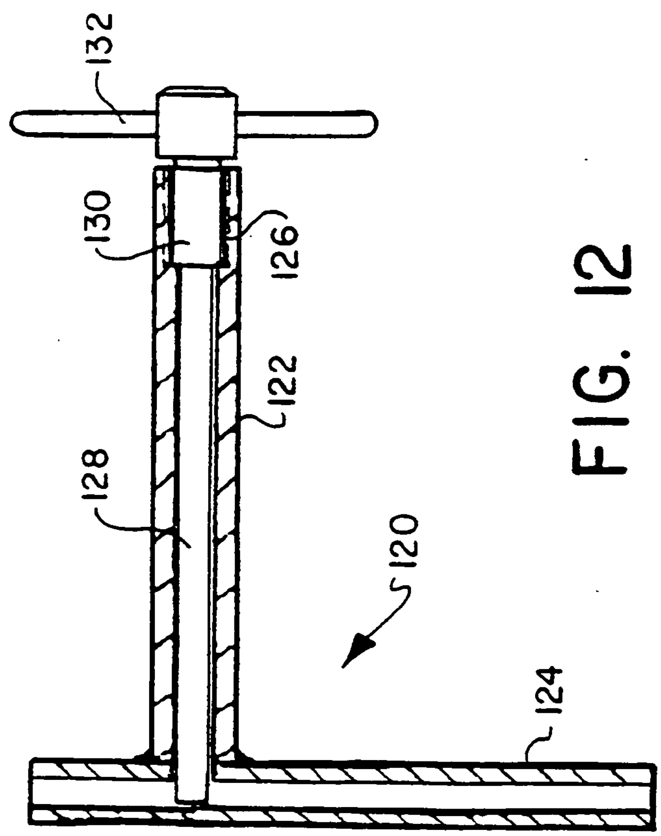


FIG. 12

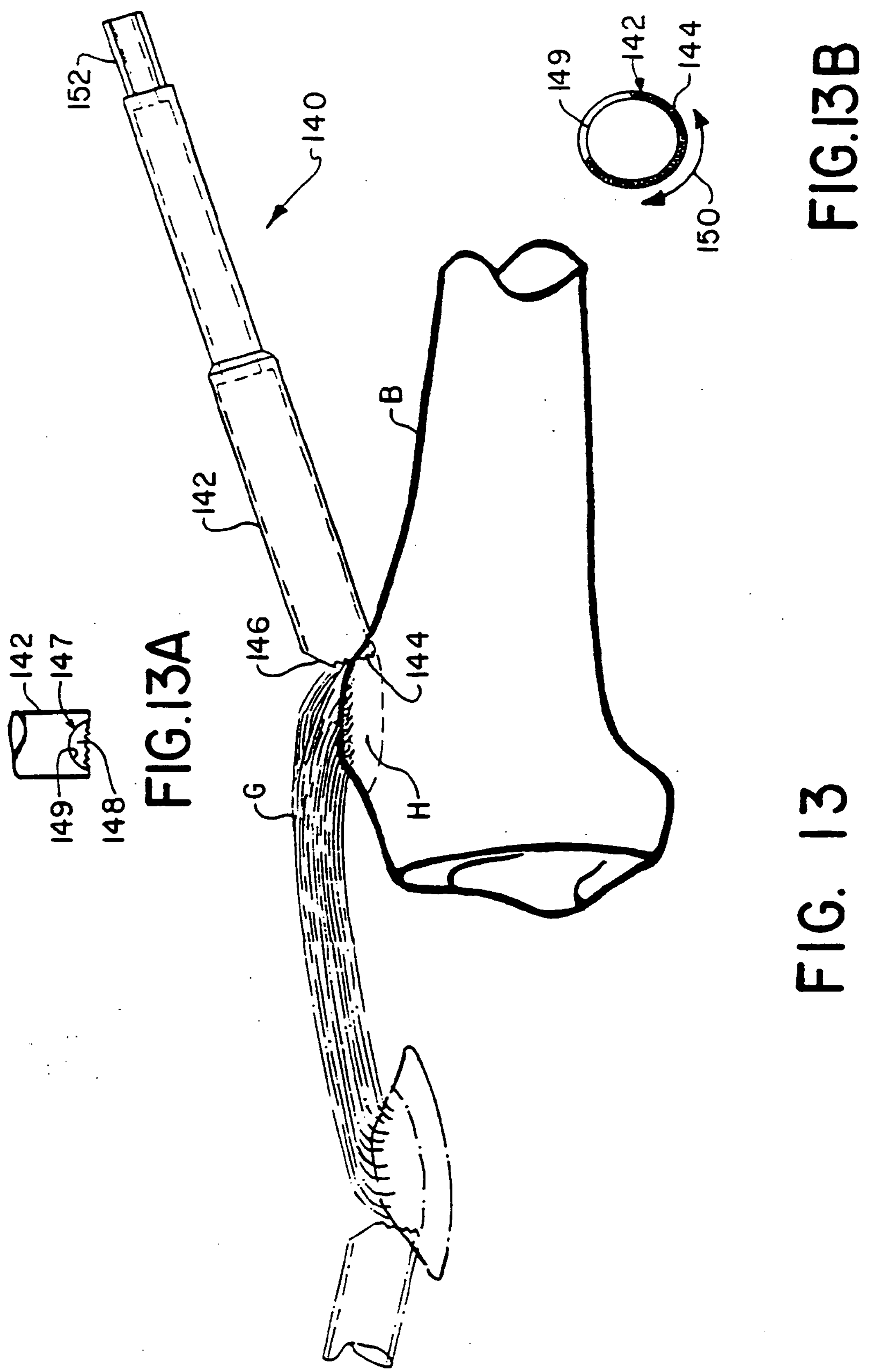


FIG.13A

FIG.13B

FIG. 13

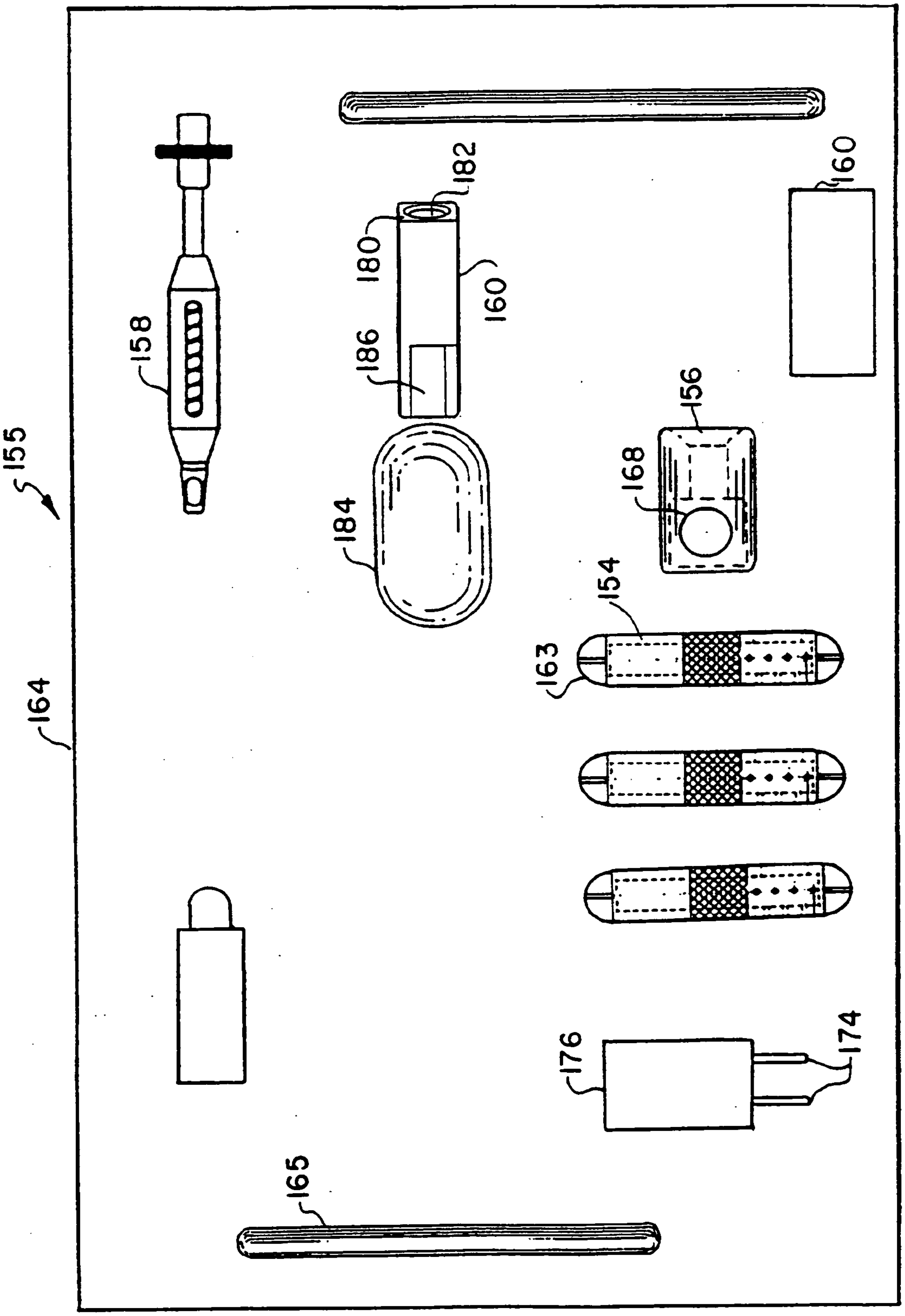


FIG. 14

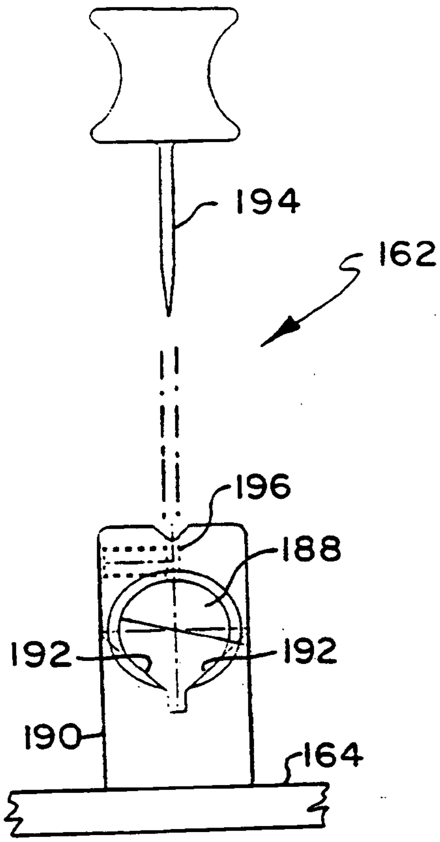


FIG. 15

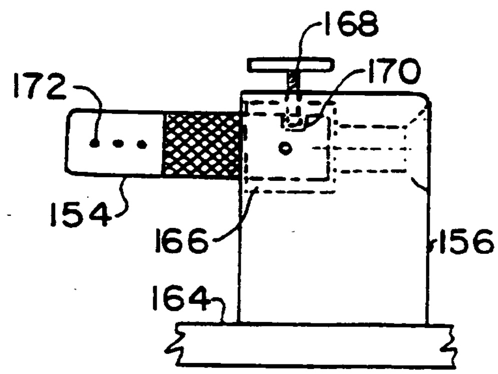


FIG. 16

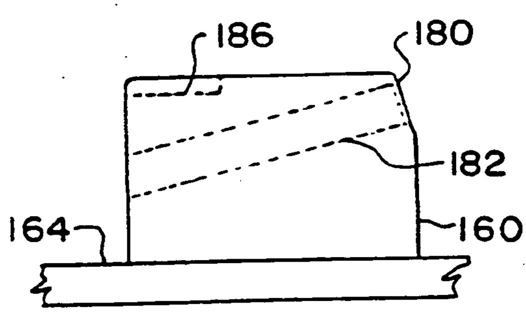


FIG. 17